

# Nitrogen

## in Minnesota Surface Waters

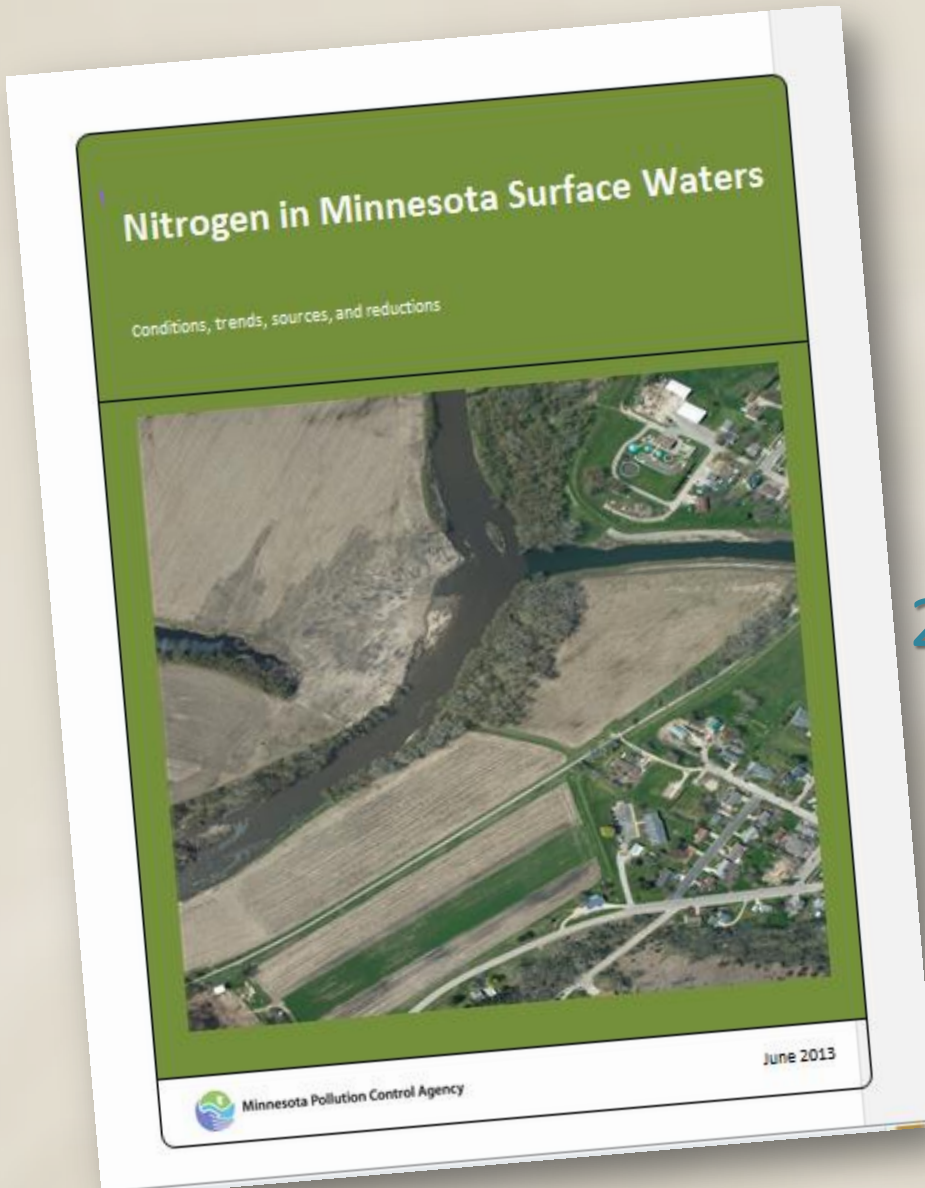
Conditions · Sources · Trends · Reductions

**Dave Wall**



Minnesota Pollution  
Control Agency

# Report finalized June 2013



15 authors and coauthors

70+ others acknowledged

20 chapters

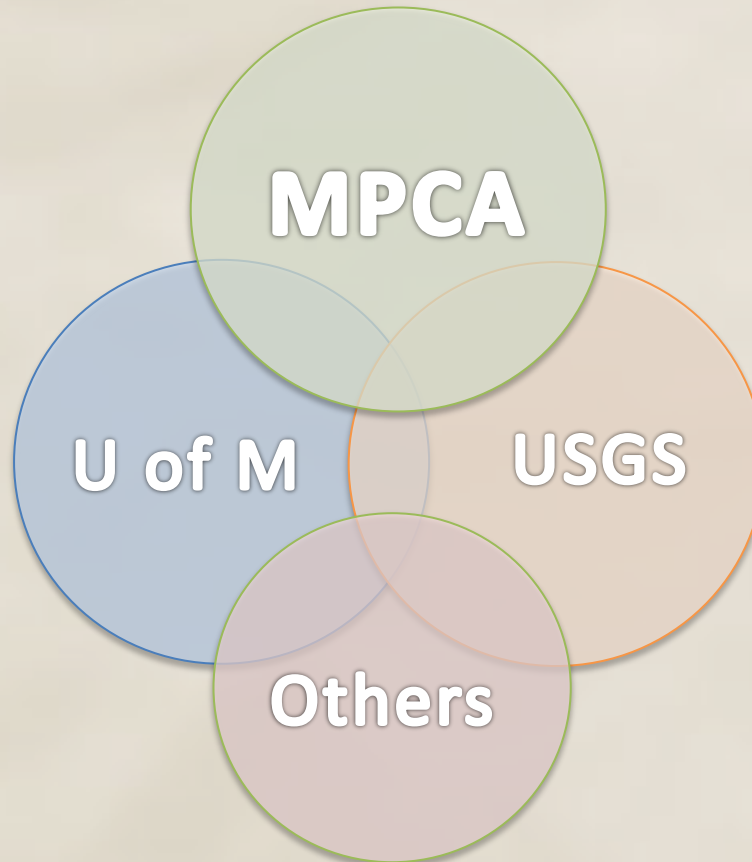
250+ maps, graphs, diagrams

20-pg Executive Summary

# Prompted study

Legislative directive

Gulf of Mexico hypoxia task force action plan



# Why we did this study

## Minnesota waters



### Aquatic life toxicity

- MPCA developing standards (2015)

### Drinking water in streams

- 15 streams exceed cold water standard

## Downstream waters



### Gulf of Mexico Hypoxia and Lake Winnipeg

- Nutrient Reduction Strategy (2013)

### Iowa Rivers

# Why do we care about nitrogen in surface water?



High concentration  
harms aquatic life

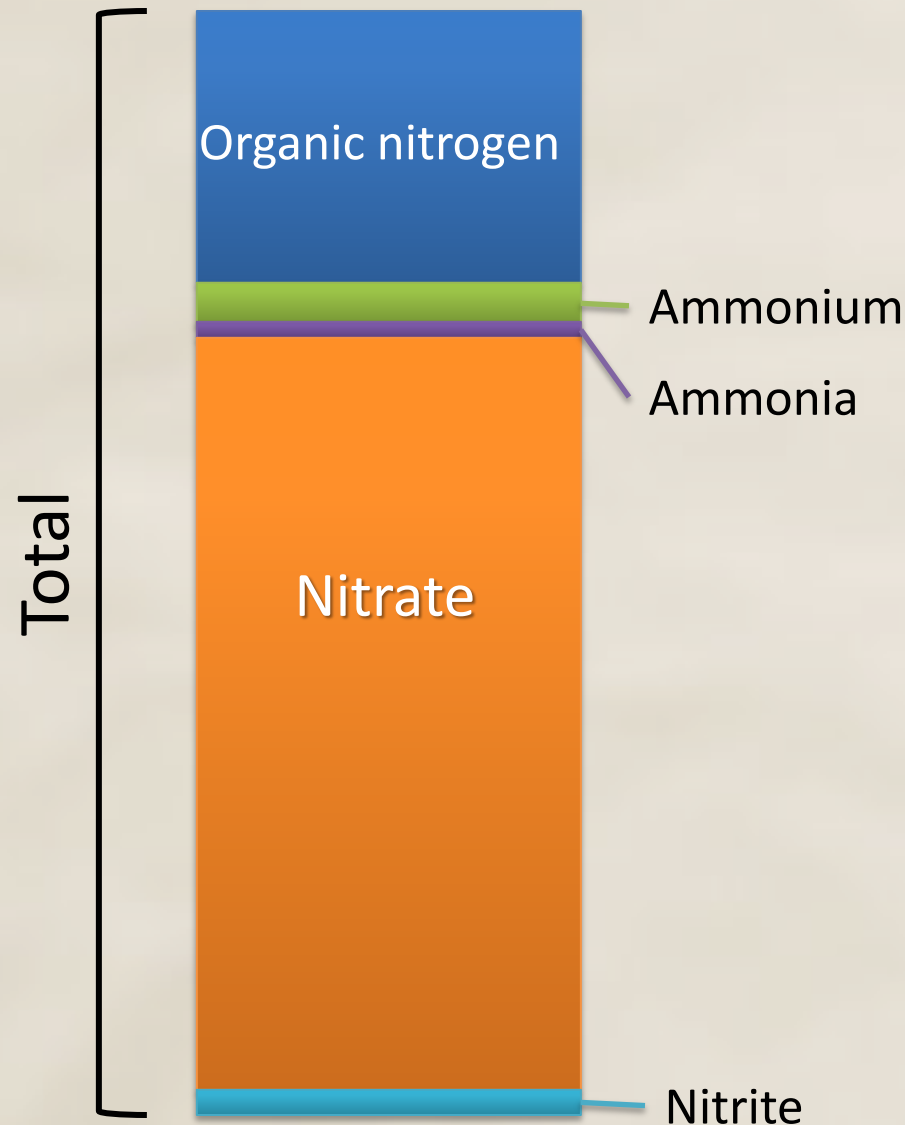


Contributes to hypoxia  
in Gulf of Mexico

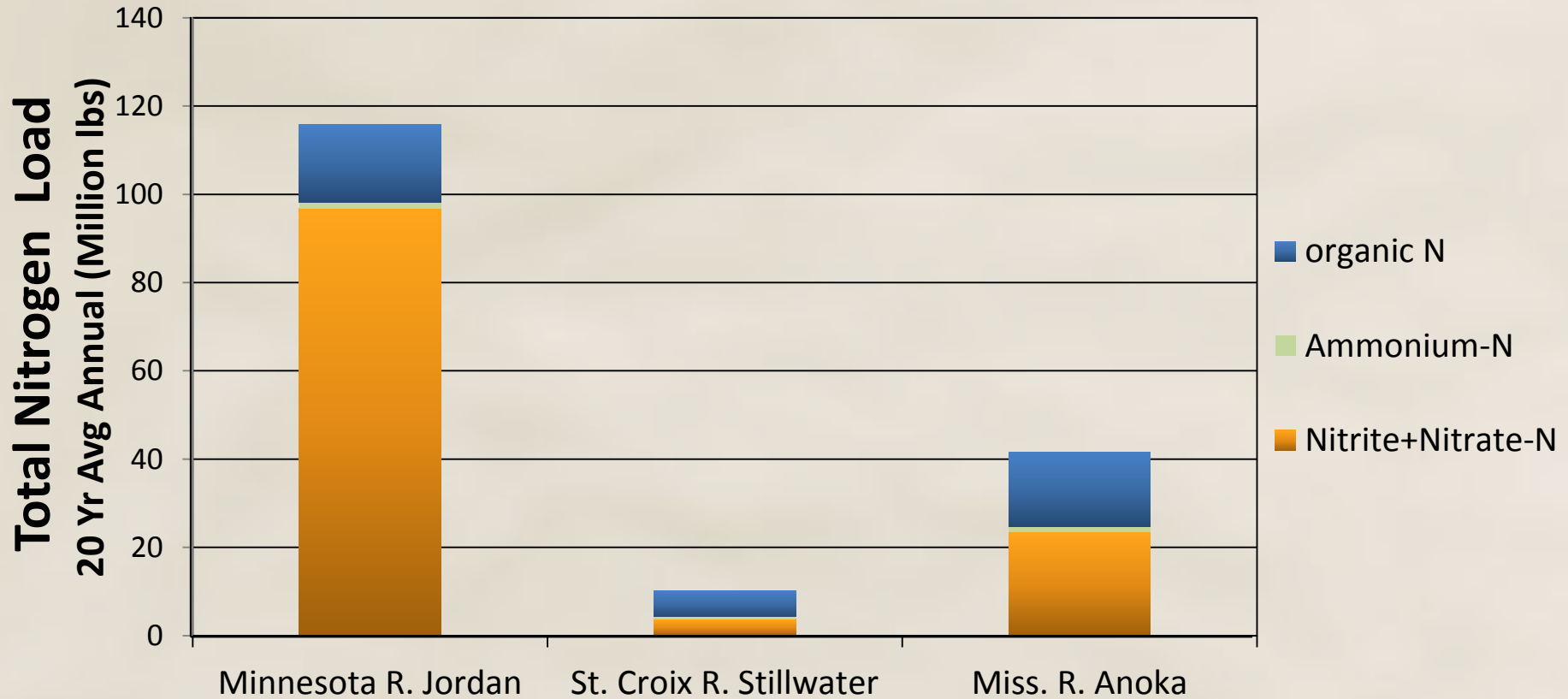


Can exceed drinking  
water standards

# Nitrate is dominant form in High N rivers



# Nitrogen forms in three rivers



# Discussion areas

Conditions

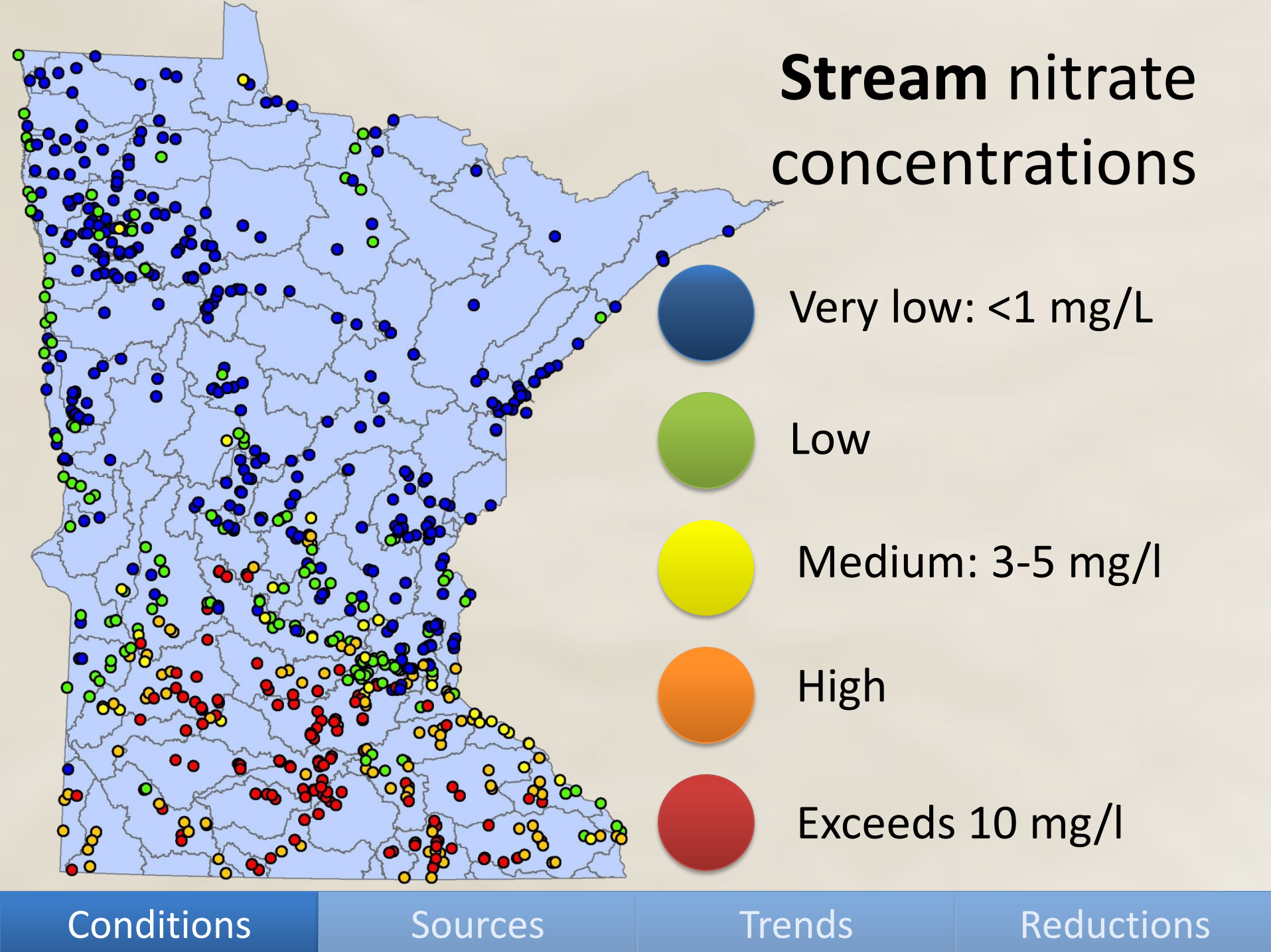
Sources

Trends

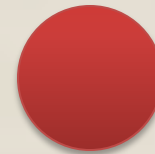
Reductions



# Stream nitrate concentrations

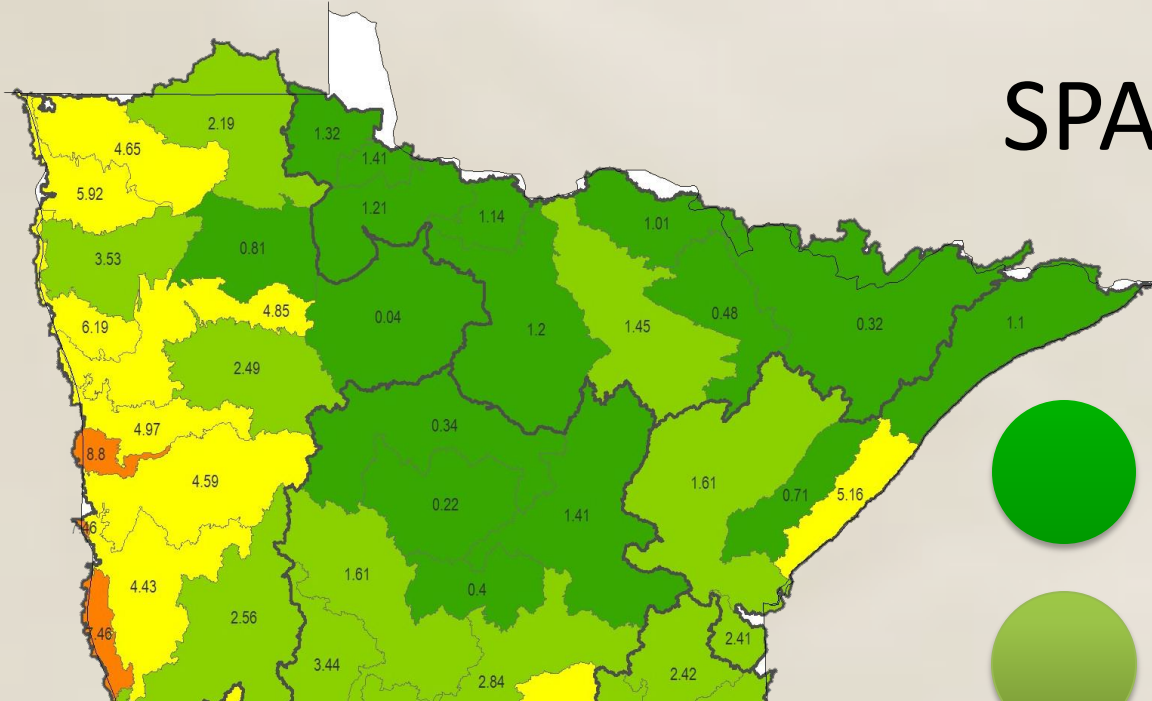


Highest 12+ lbs/ac/yr



# Reductions

# SPARROW modeling of nitrogen yield



1/3 watersheds =  
3/4 load to Mississippi



Very Low <1.4 lb/ac/yr



Low



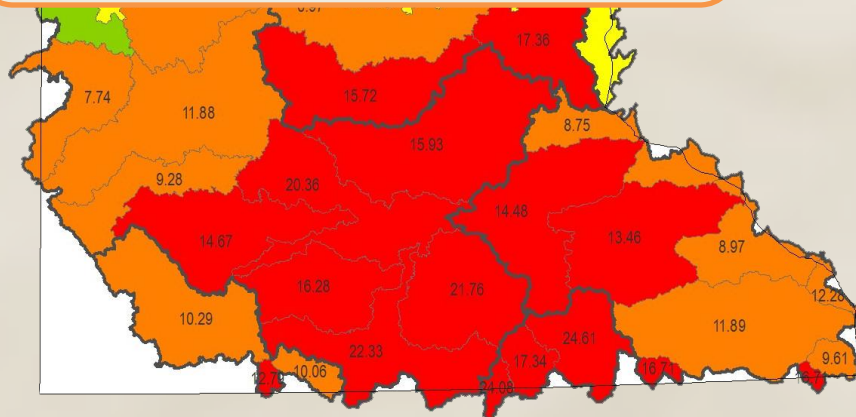
Medium



High



Highest 12+ lb/ac/yr



Conditions

Sources

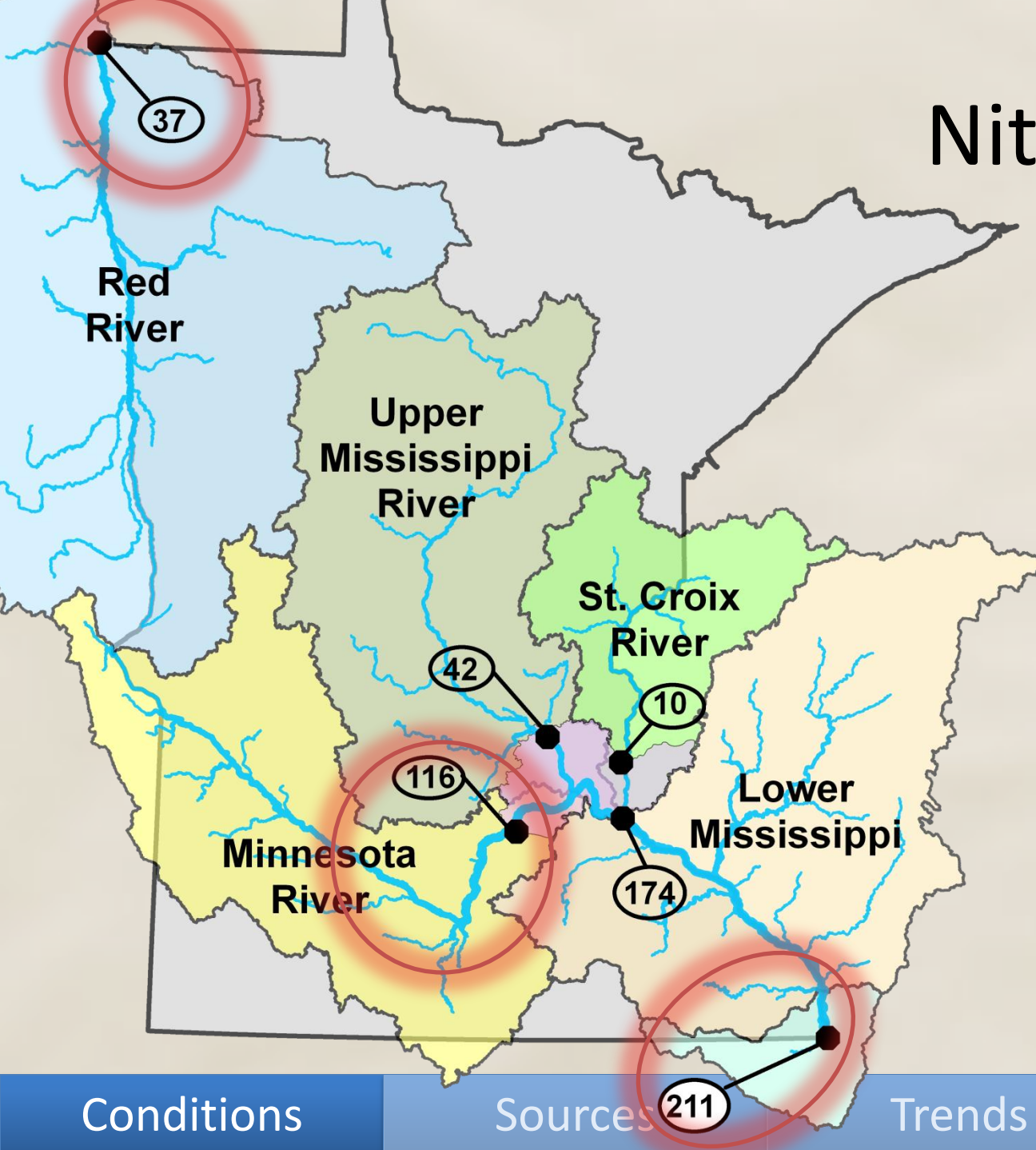
Trends

Reductions



# Nitrogen Loads

long-term average



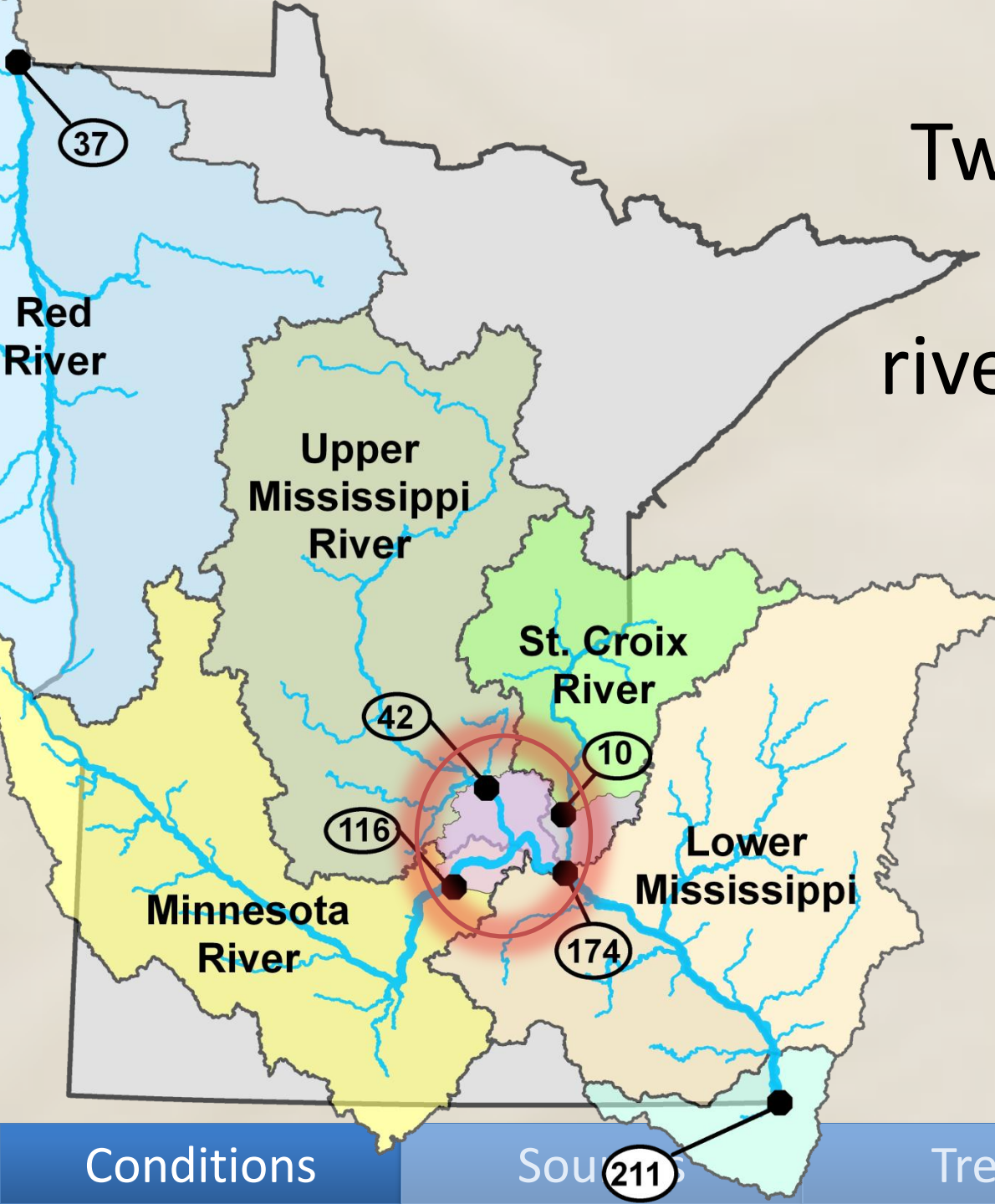
Conditions

Sources

Trends

Reductions

Twin Cities region  
added 3.5% to  
river nitrogen load



Conditions

Sou 211

Trends

Reductions

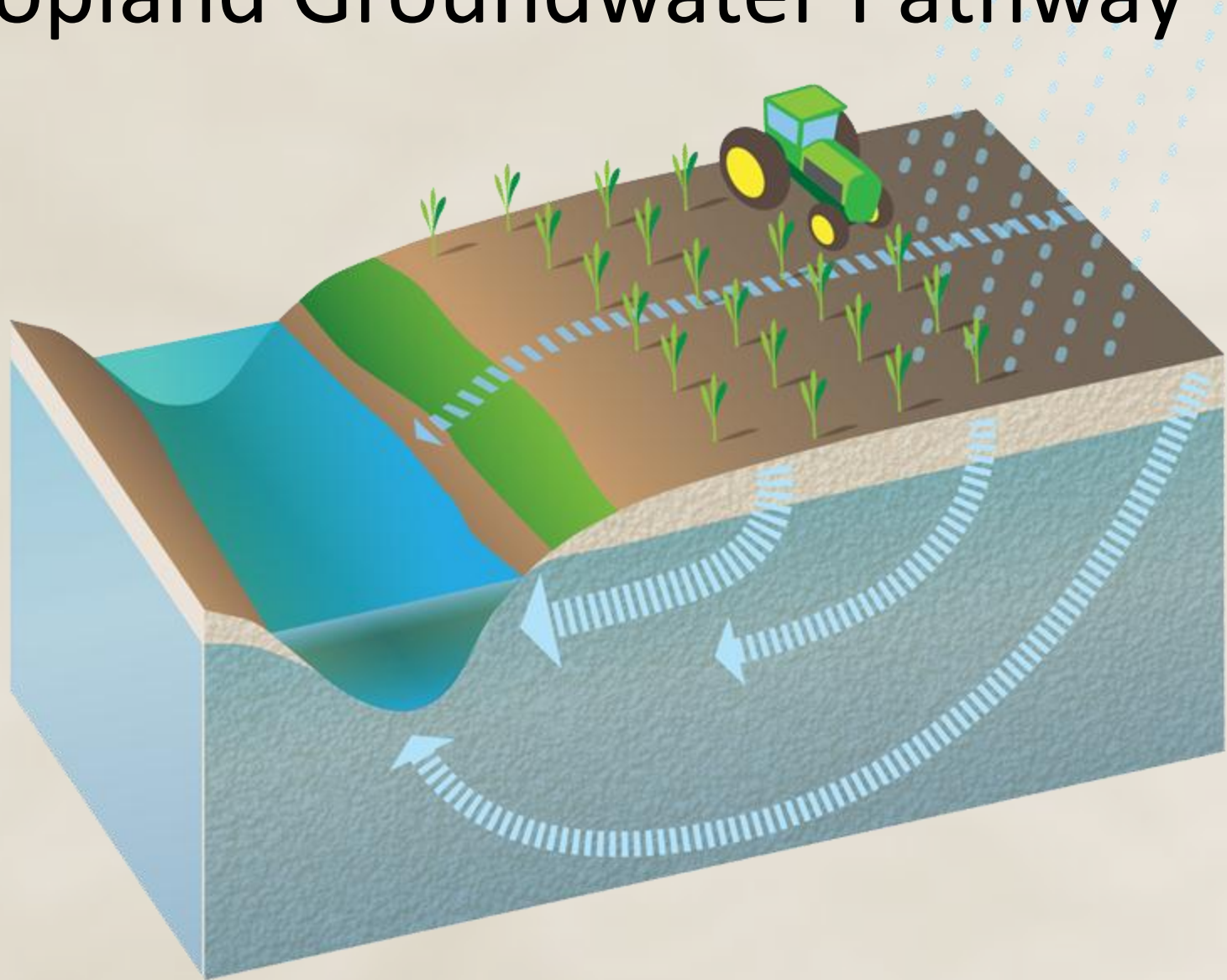
Conditions

Sources

Trends

Reductions

# Cropland Groundwater Pathway



Conditions

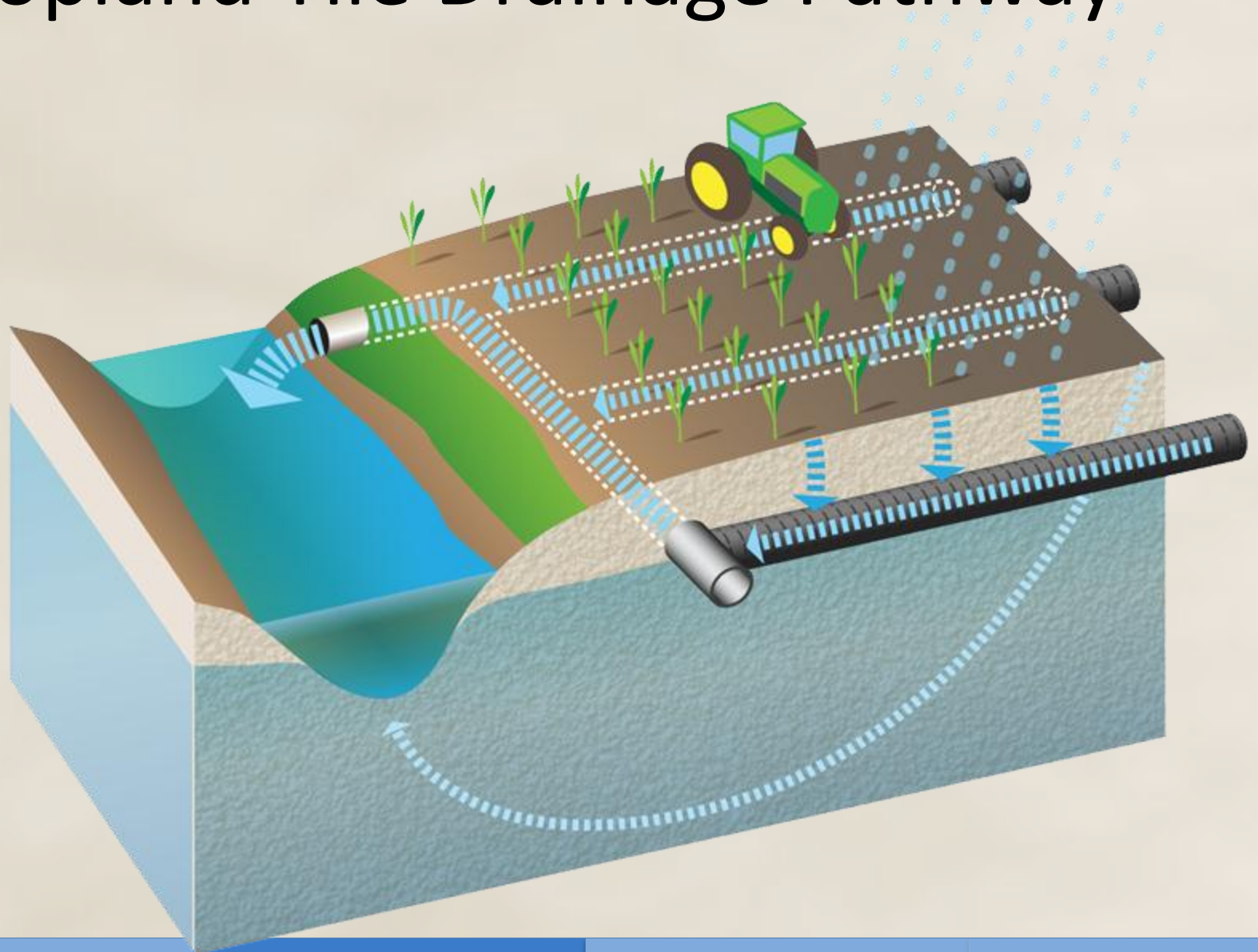
Sources

Trends

Reductions



# Cropland Tile Drainage Pathway



Conditions

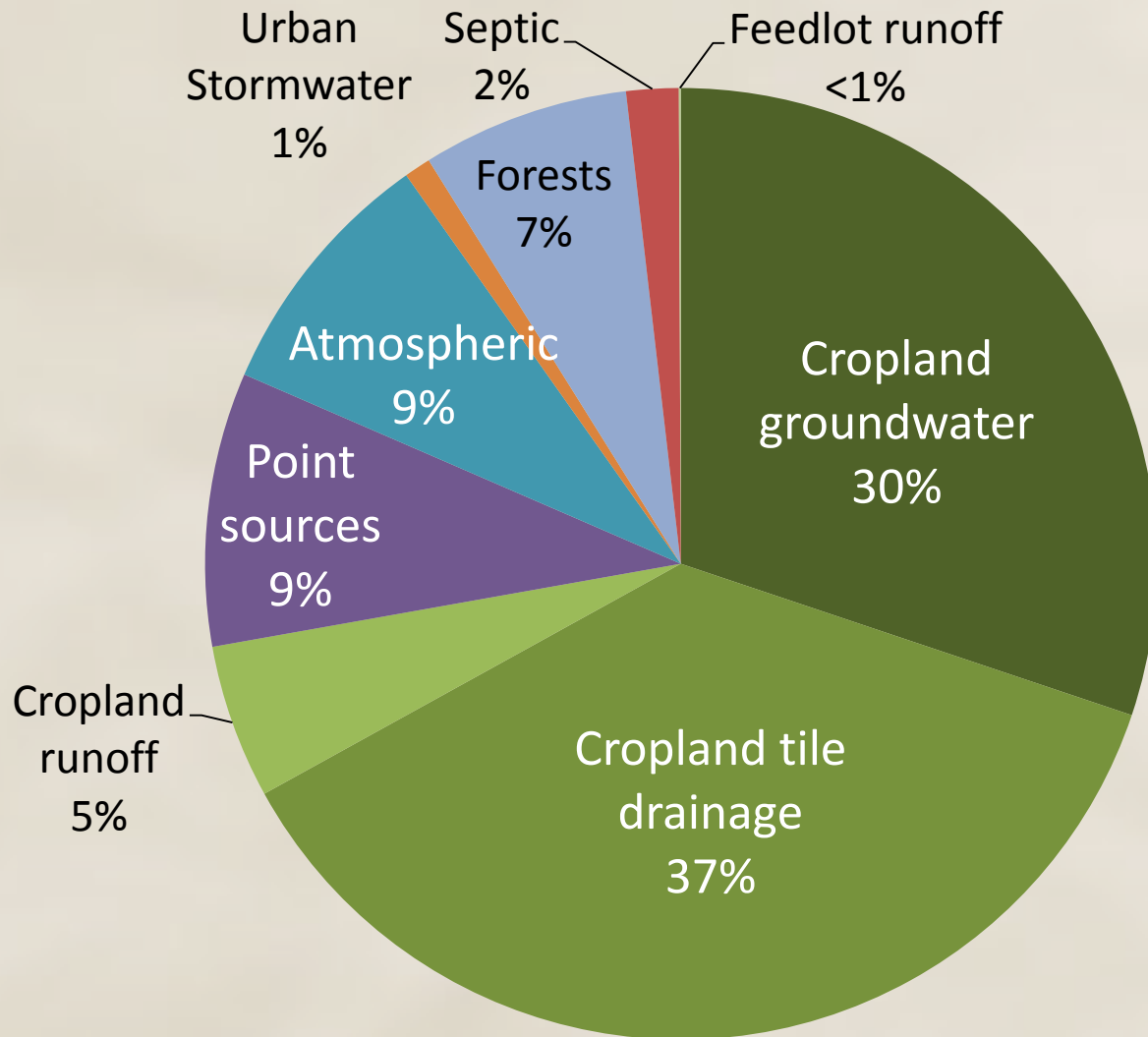
Sources

Trends

Reductions



# Statewide nitrogen sources to surface waters



Conditions

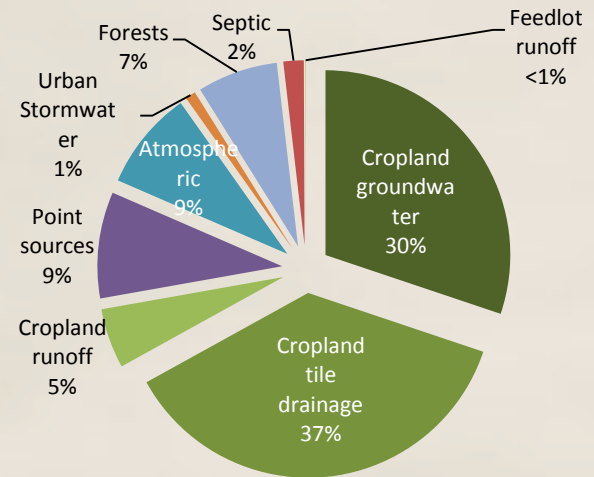
Sources

Trends

Reductions

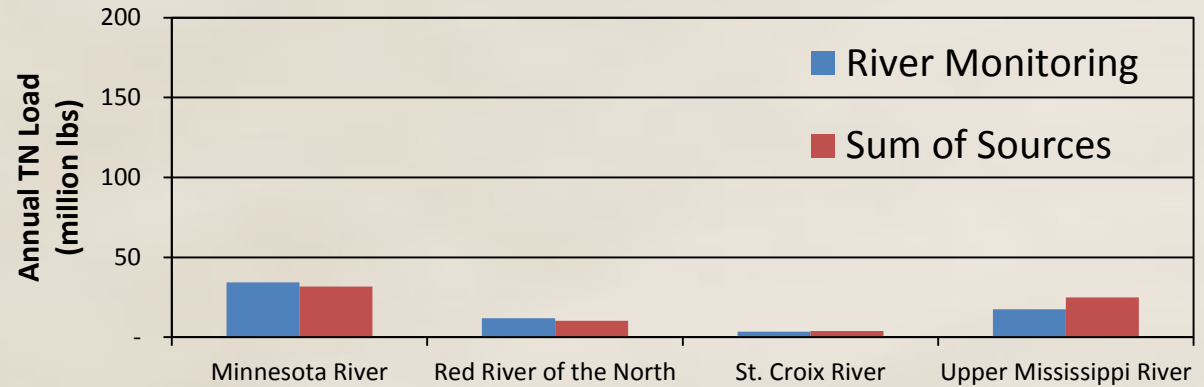
# N source estimates checked with:

1. Water Monitoring
2. Literature review - MN and Upper Midwest
3. Statistical and non-statistical analyses comparing land uses and watershed N levels
4. U.S. Geological Survey Modeling (SPARROW)
5. Modeling in Minnesota River Basin (HSPF)
6. Sensitivity Analyses

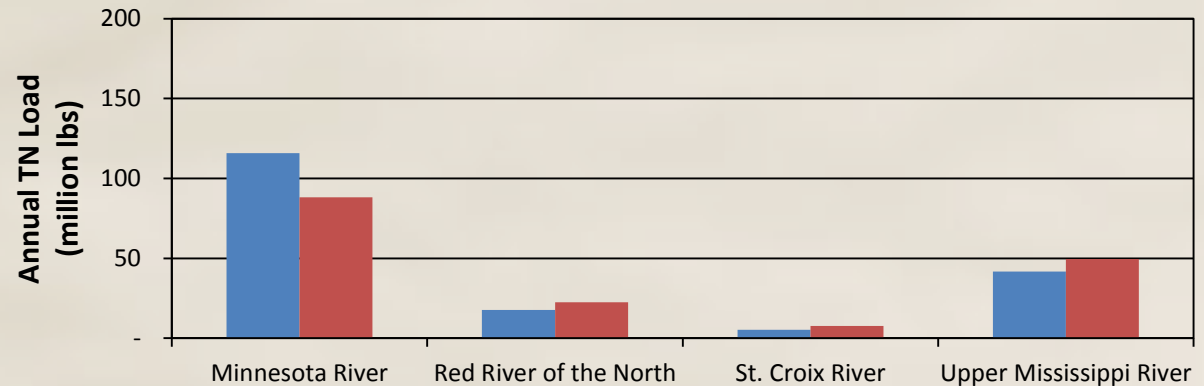


# Comparing nitrogen loads

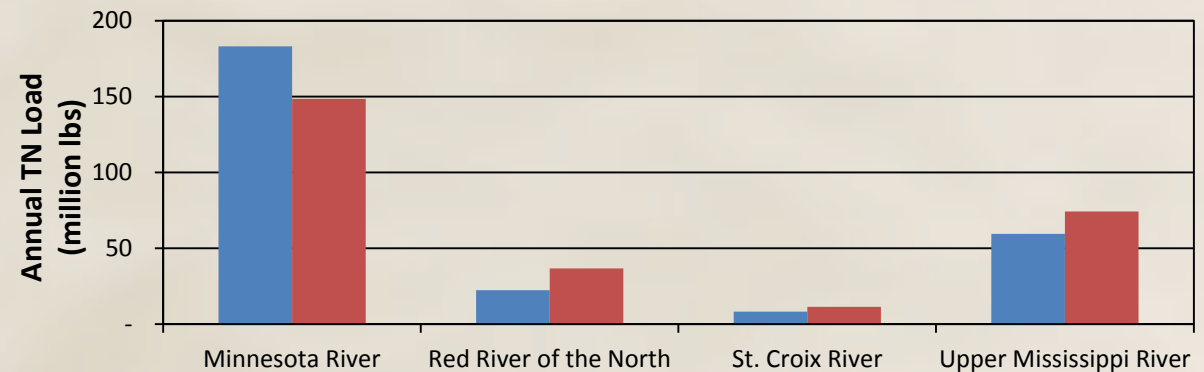
Dry year



Ave. year



Wet year



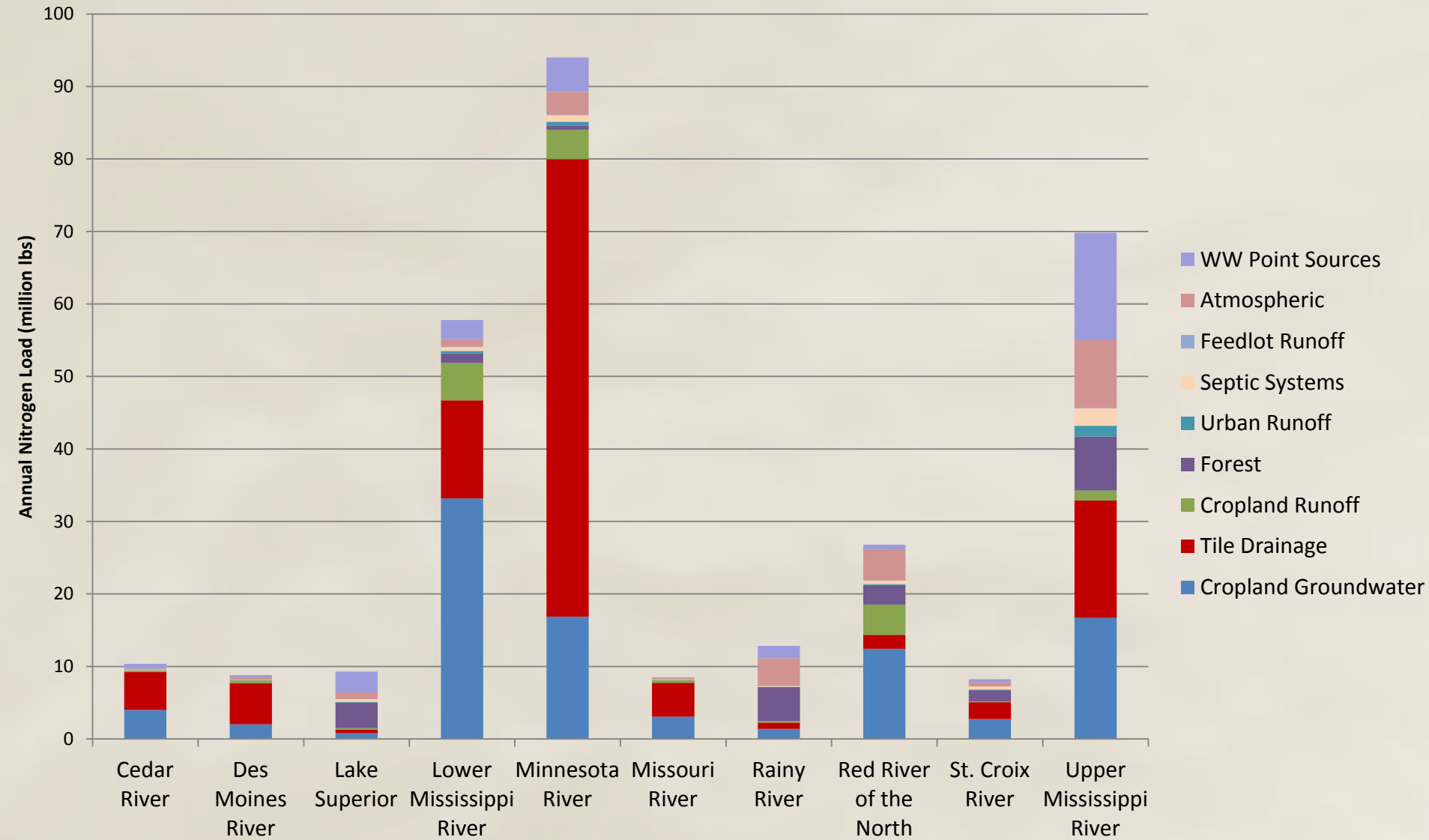
Conditions

Sources

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# Nitrogen sources to surface waters



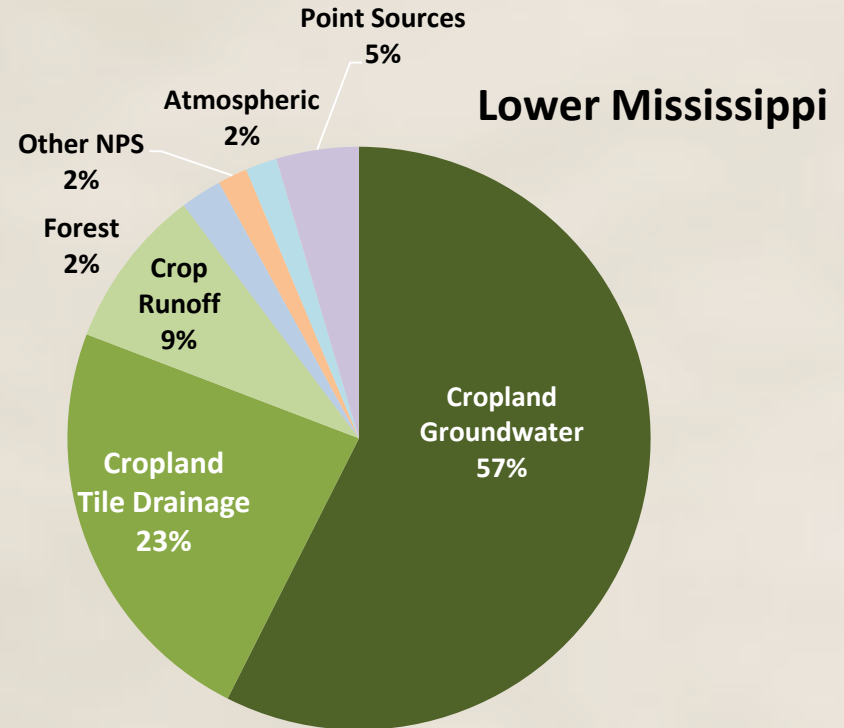
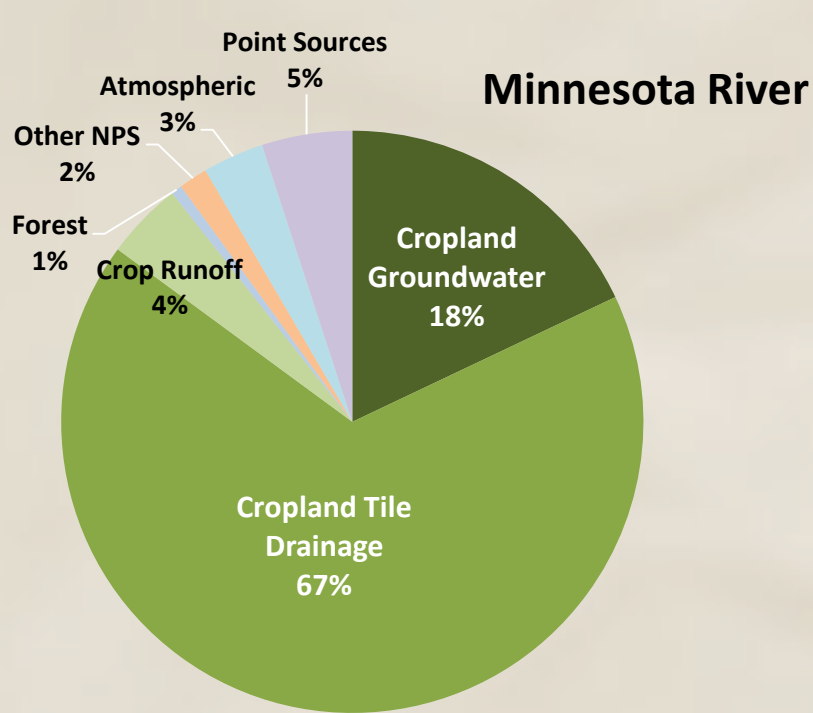
Conditions

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# Nitrogen source differences between basins



Conditions

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**How Nitrate Levels Vary by Watershed**

**% watershed tile-drained (estimated)**

50  
45  
40  
35  
30  
25  
20  
15  
10  
5  
0

Low  
(0.05 to 0.5)

**Nitrate Levels**

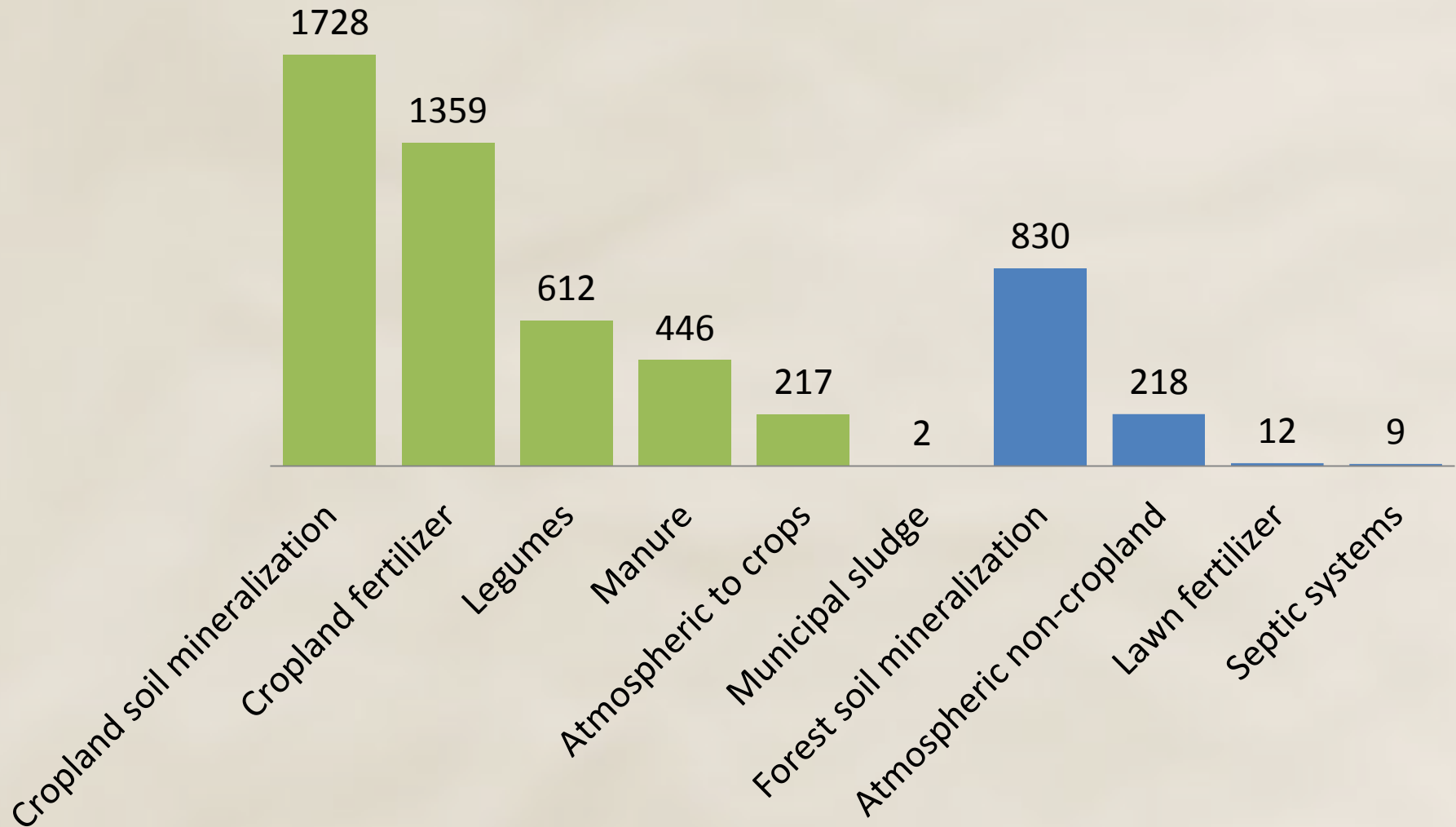
A box plot titled 'Nitrate Concentrations in Watersheds (FWMC mg/L)' showing the distribution of nitrate concentrations across four categories: Low (0.05 to 0.5), Medium (0.6-1.9), High (4.8-7.1), and Very High (7.9-9.5). The y-axis represents the concentration in mg/L, ranging from 0 to 50. Each category is represented by a colored box: Low is green, Medium is yellow, High is orange, and Very High is red. A horizontal line within each box indicates the median, and the box itself represents the interquartile range (IQR). The plot shows that as the category increases, the median nitrate concentration and the range of concentrations also increase.

Category	Min	Q1	Median	Q3	Max
Low (0.05 to 0.5)	0.05	0.1	0.2	0.3	0.5
Medium (0.6-1.9)	0.6	0.8	1.0	1.5	1.9
High (4.8-7.1)	4.8	6.5	7.0	8.5	9.5
Very High (7.9-9.5)	7.9	8.5	9.0	9.5	9.5

# Reductions

# Sources to soils

Note: Do not equate with sources to waters



Conditions

Sources

Trends

Reductions

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# Nitrate Concentrations

Flow Adjusted



Increase

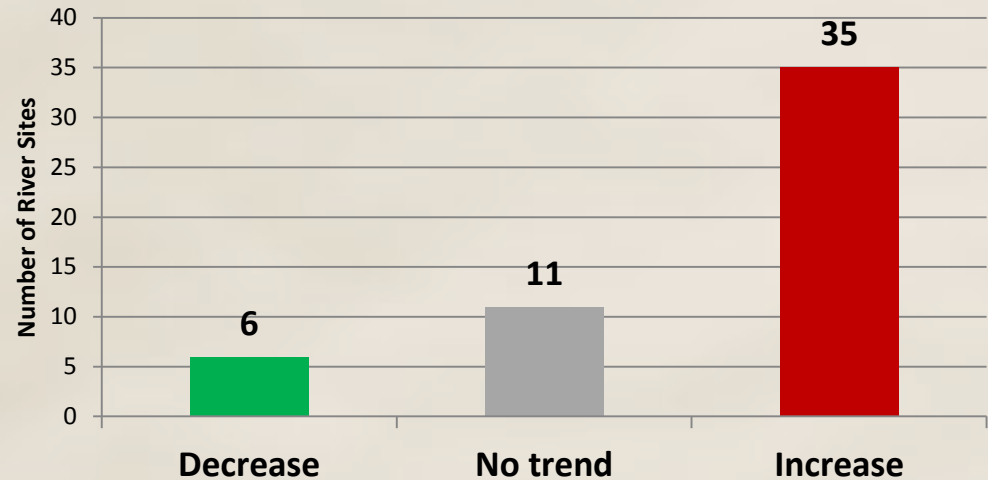


Decrease

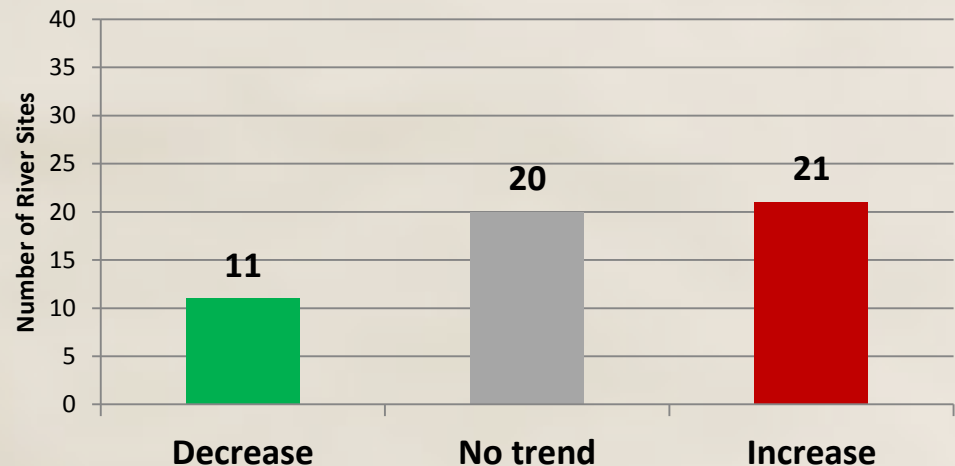


No trend

1976 to 2010  
52 River Monitoring Sites



Recent Trends  
52 River Monitoring Sites

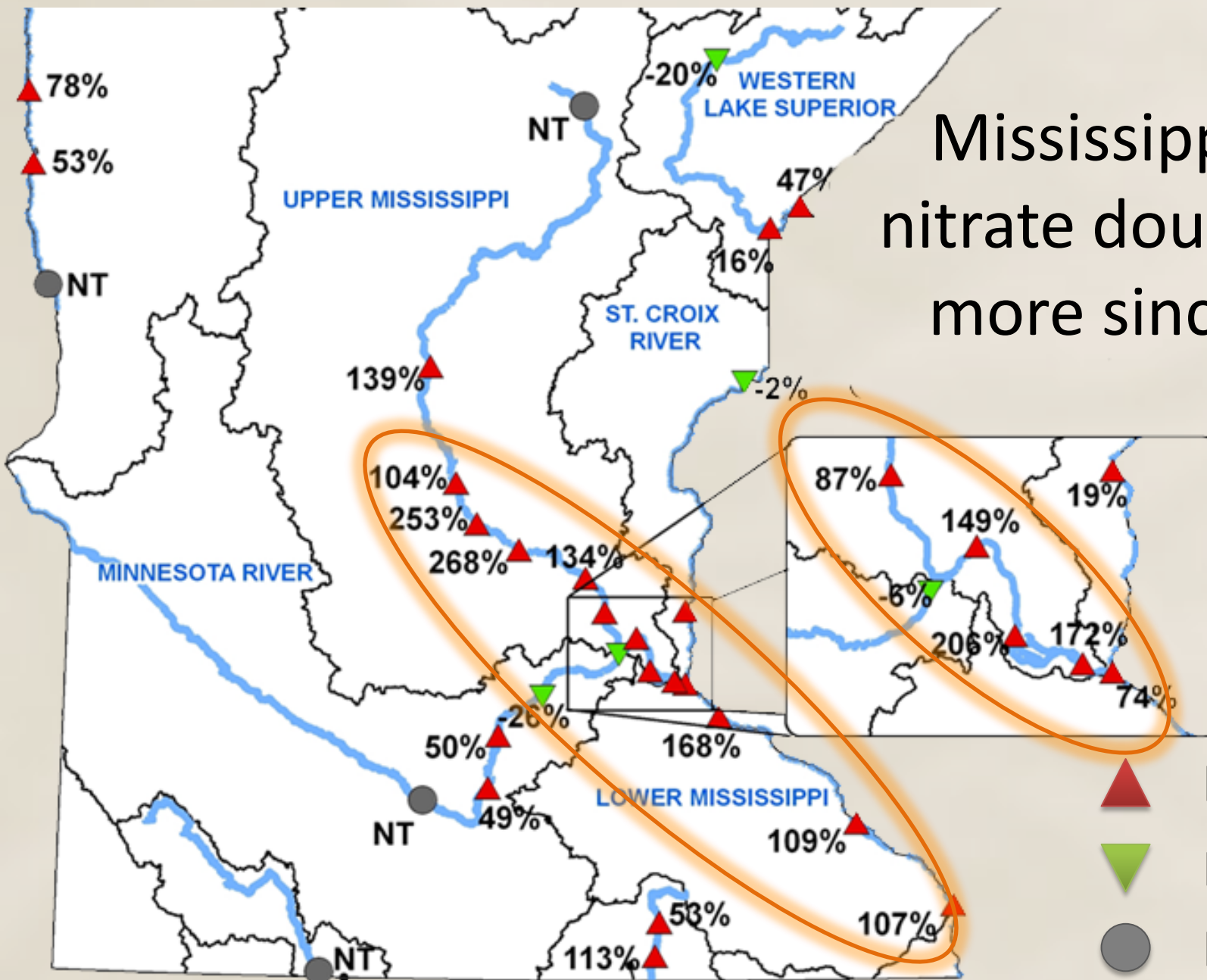


Conditions

Sources

Trends

Reductions



Mississippi River  
nitrate doubled or  
more since 1976

- ▲ Increase
- ▼ Decrease
- No trend

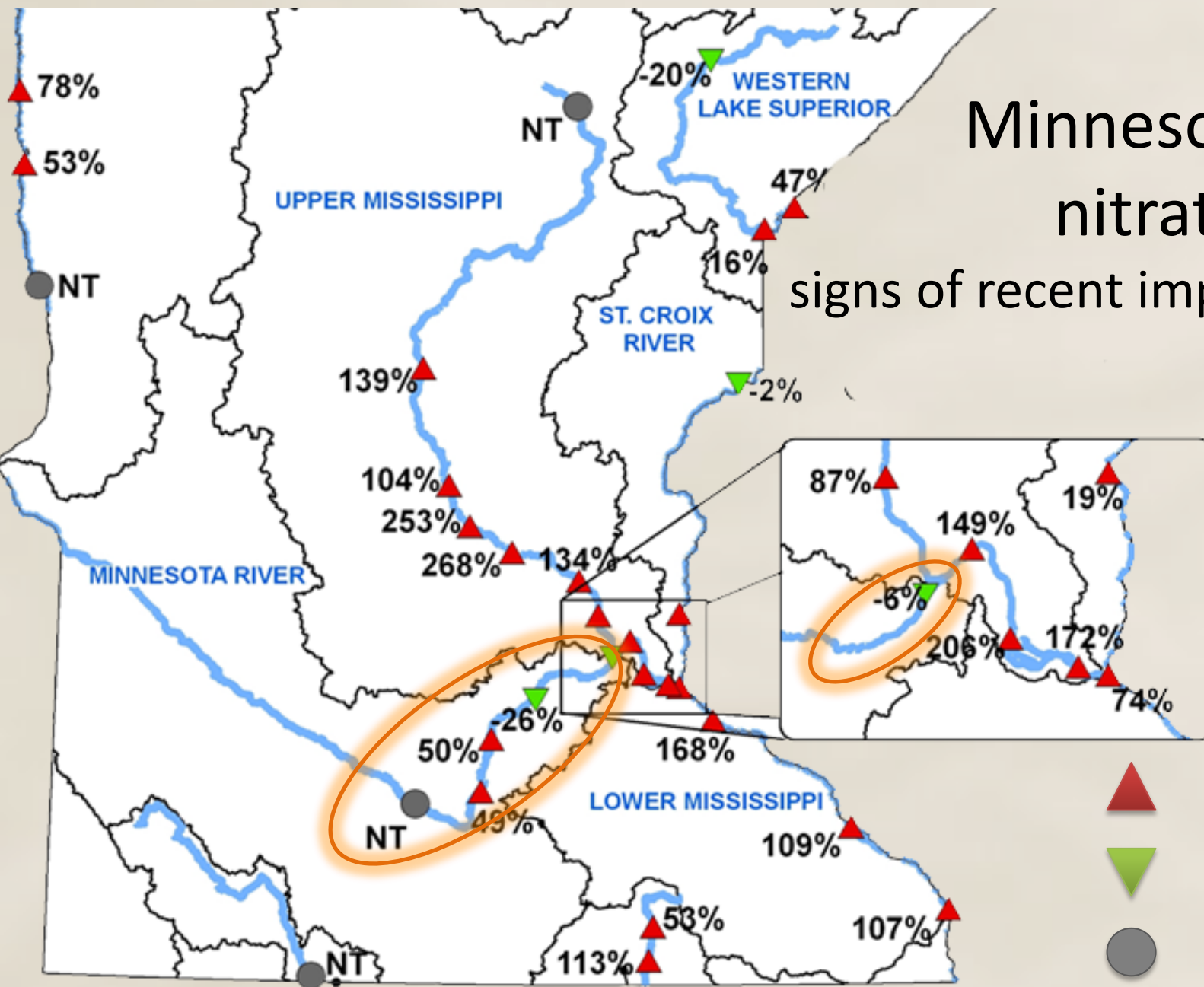
Conditions

Sources

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Reductions

# Minnesota River nitrate high – f recent improvement



- ▲ Increase
- ▼ Decrease
- No trend

## Conditions

## Sources

# Trends

# Reductions

Conditions

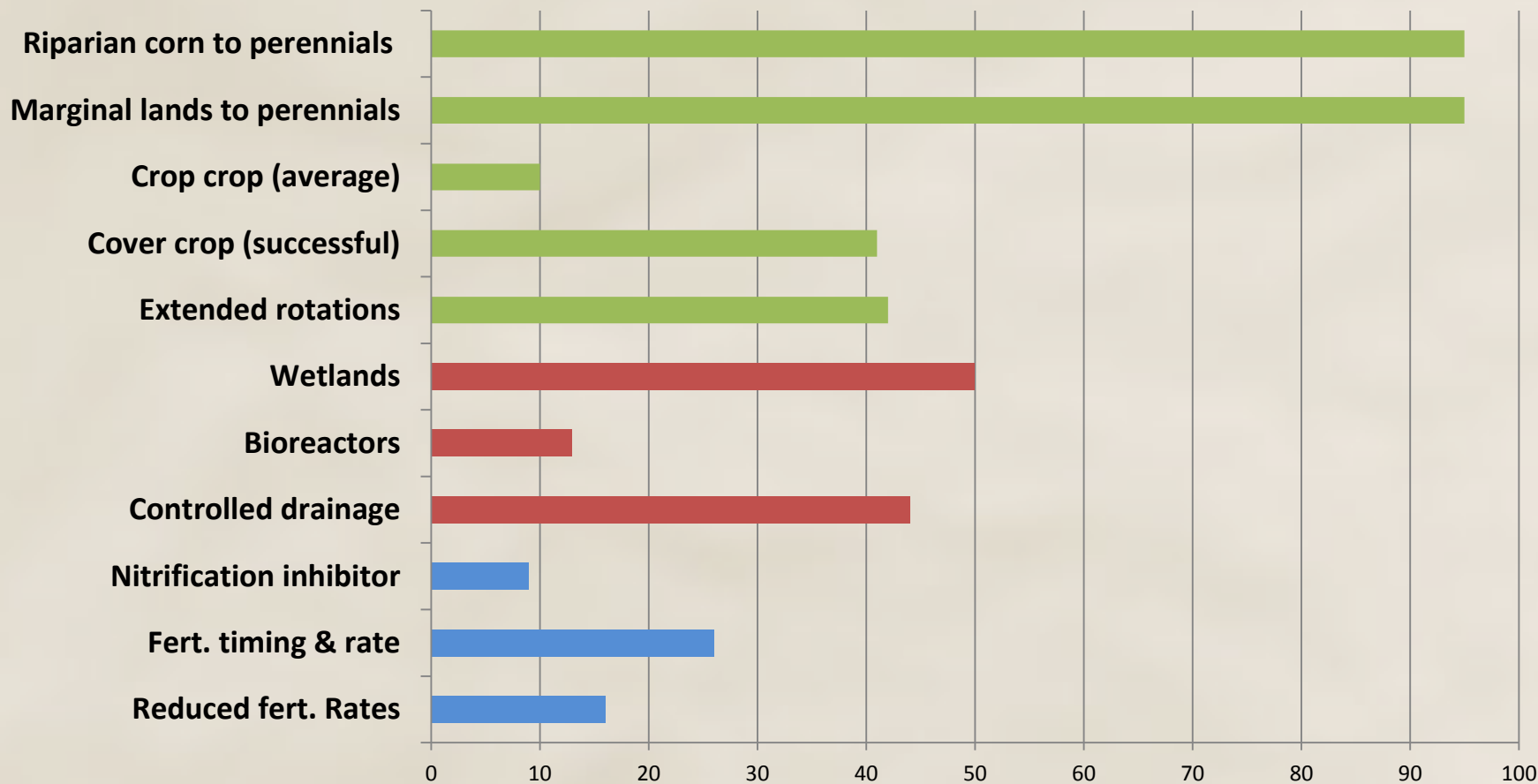
Sources

Trends

Reductions

# Percent nitrogen reduction **in treated area**

**% N reduction in treated area**



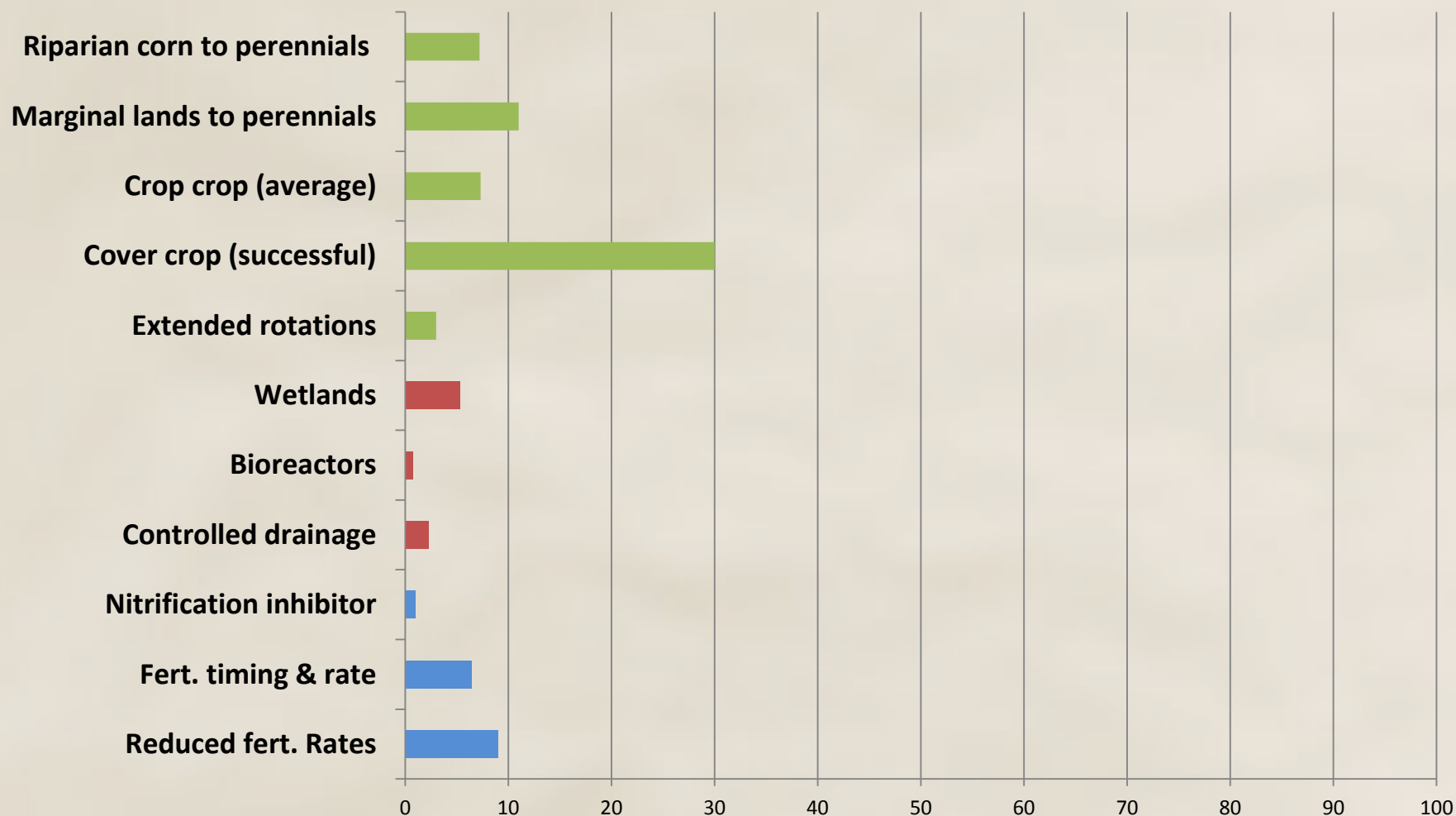
Conditions

Sources

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Reductions

# Percent N reduction to waters statewide



Conditions

Sources

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Reductions

# Spreadsheet – N reduction scenarios

Statewide

Corn grain & silage acres receiving the target N rate

Fall N applications switched to spring, % of fall-app. acres

Fall N switch to split spring/sidedressing, % of fall acres

Riparian buffers

Restored wetlands

Tile line bioreactors

Controlled drainage

Corn & soybean acres planted w/cereal rye cover crop

Marginal land perennial crop replacing corn & soybean

Average weather - all of preplant N is available

1	29.685 % suitable	million acres in watershed % adoption	% treated	% treated, combined
	26.2%	90%	23.6%	23.6%
	10.5%	45%	4.7%	4.7%
	10.5%	45%	4.7%	4.7%
	5.8%	70%	4.0%	4.0%
	5.3%	50%	2.7%	2.7%
	4.5%	20%	0.9%	0.9%
	4.5%	50%	2.3%	2.3%
	50.1%	10%	5.0%	4.6%
	5.8%	10%	0.6%	0.3%

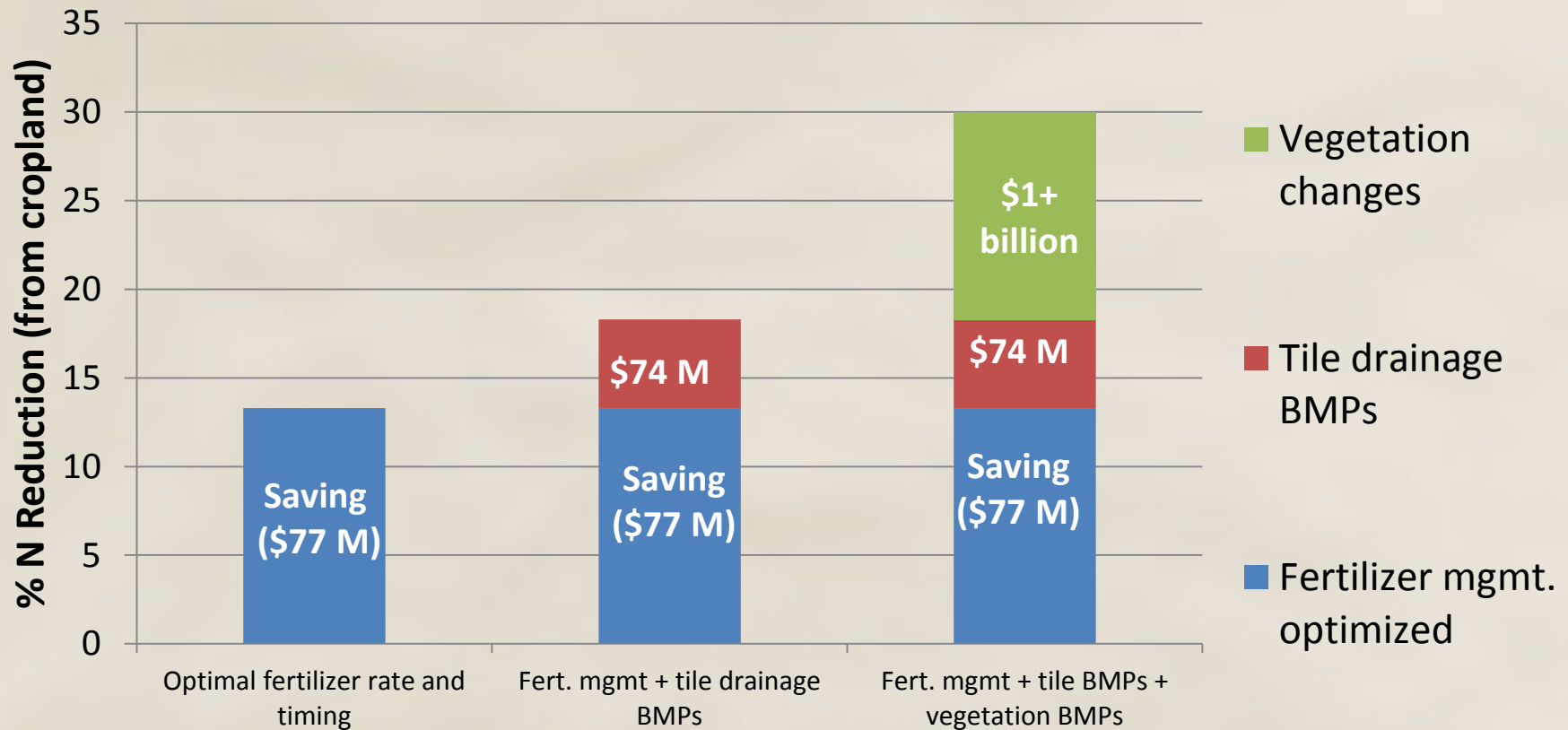
## Minnesota Watershed Nitrogen Reduction Planning Tool

William Lazarus  
Department of Applied Economics  
University of Minnesota

David Mulla  
Department of Soil, Water, and Climate  
University of Minnesota

David Wall  
Minnesota Pollution Control Agency

# Reducing cropland nitrogen losses to surface waters statewide



*Cost estimates subject to change with fluctuating markets*

Conditions

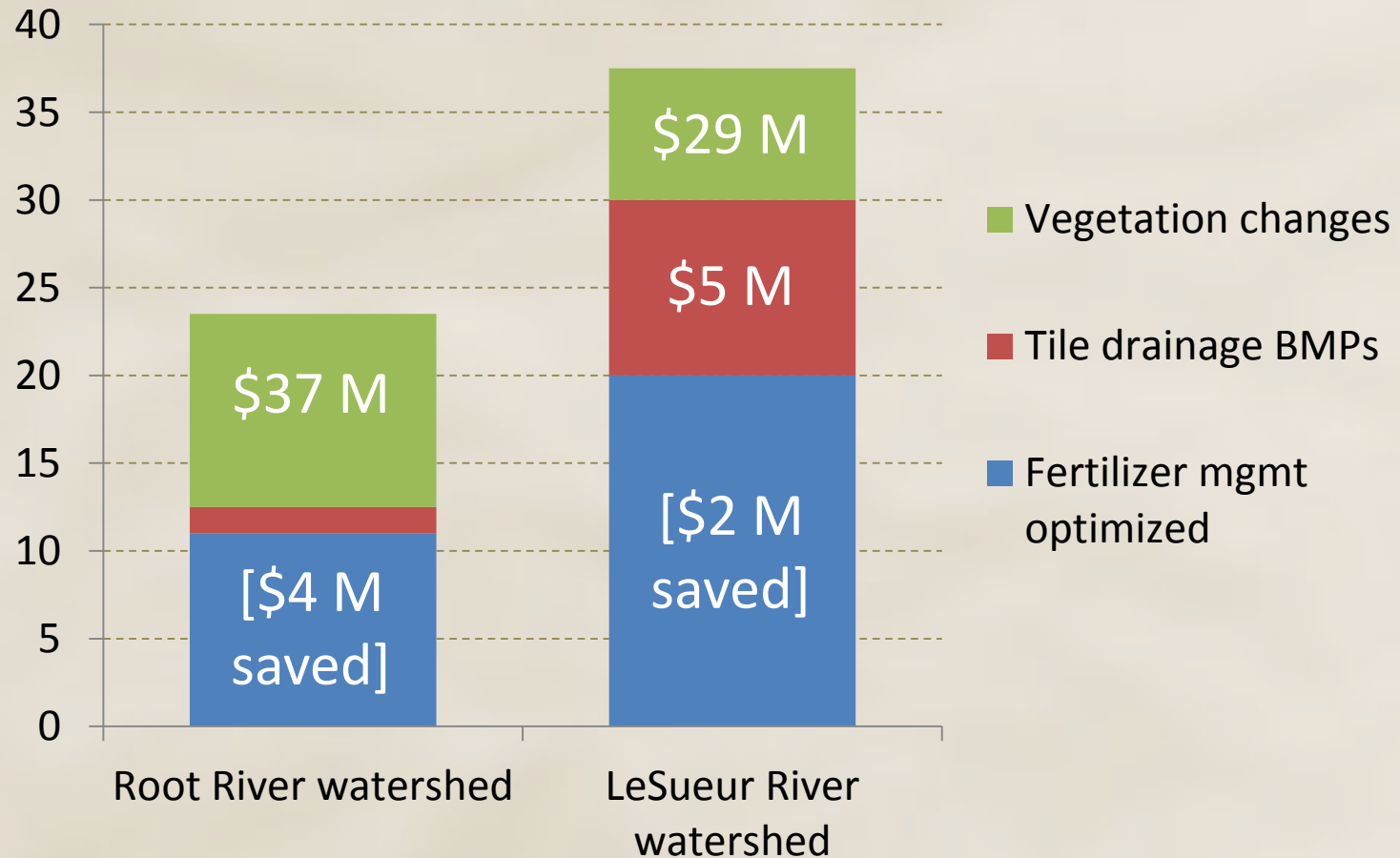
Sources

Trends

Reductions



# Nitrogen reduction potential and costs vary by watershed



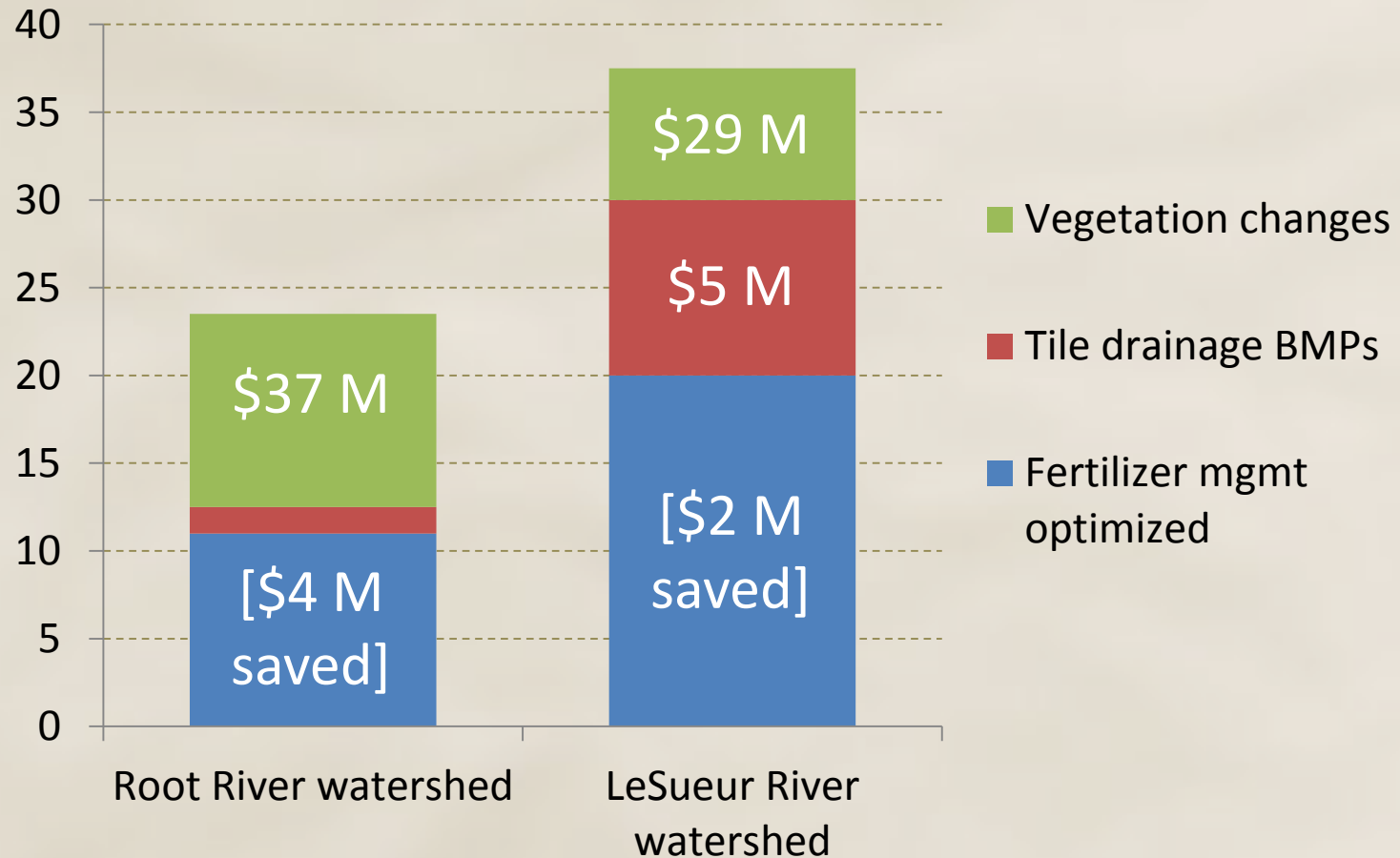
Conditions

Sources

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Reductions

# Nitrogen reduction potential and costs vary by watershed



Conditions

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# Reducing nitrogen in wastewater discharges

9% of nitrogen load  
to rivers

Can reduce by 35-65%



Conditions

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# Conclusions

1

High nitrate in Southern Minnesota –  
cropland nitrate leaching to tile lines and groundwater

2

Concentrations increasing in Mississippi R since mid-1970's  
Minnesota River high – may be stabilizing/decreasing

3

Can reduce nitrogen losses to rivers:

- 15-20% through fertilizer mgmt + tile water treatment
- More vegetative cover needed for further reductions

# Some continuing work

Nitrogen Fertilizer Management Plan	2013
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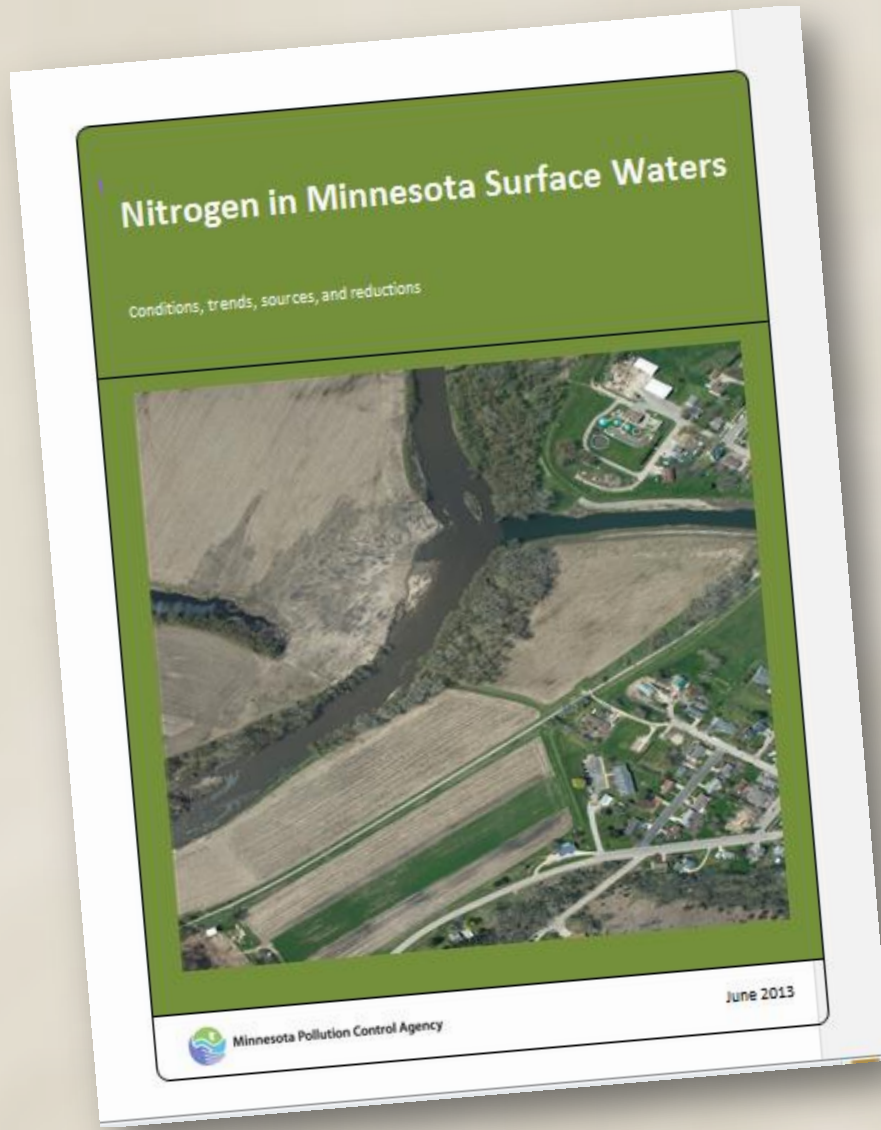
Agricultural Water Quality Certification Pilots	2013
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State-level Nutrient Reduction Strategy	2013
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River nitrate standards	2015
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# Questions??

[www.pca.state.mn.us/6fwc9hw](http://www.pca.state.mn.us/6fwc9hw)



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